Draft

ISCI 360 *Systems Approaches to Regional Sustainability*

Syllabus 2013

Contemporary scientists agree that solutions to complex **global challenges such as environmental sustainability calls for "systems thinking"**: the process of understanding how component elements influence each other within a whole. Systems thinking as an approach to problem-solving argues that the component parts of a system can best be understood in the context of relationships with each other and with other systems, rather than in isolation.

A scientific approach to examining the world that embraces systems thinking therefore demands that we consider landscapes, regions or whole continents as systems. In these systems, elements such as land, air, water, climate, plants, animals, and even human societies interact in ways that influence the likelihood that the system will survive or perish.

This course is designed to challenge students to draw together knowledge and learning from a range of scientific disciplines and to pursue a systems thinking approach in the investigation of selected regions of the world.

This course will introduce students to the study of various components of regional systems, using selected regions as illustrative case studies. These will include the influence of geological and hydrological systems in shaping the land; factors influencing local climate; the influence of climate, water and land on marine and terrestrial ecosystems; the resultant influences on food availability and production; and current local challenges, with a particular focus on stability and sustainability of regional systems.

- Describe the 'three dimensions' model of sustainability, and its relevance as a framework in which to analyze and address global problems.
- Discuss the ways that science and earth systems science can and should contribute to the promotion of global sustainability.
- Describe the principles of systems thinking, and explain its importance as an approach to thinking about complex global problems.
- Understand the fundamental connectedness of geological, hydrological, ecological, atmospheric and human systems, and the contributions of different scientific disciplines to their study.
- Outline the connected factors that have influenced evolution of example regional systems.

This term-long 3-credit course is offered in 'hybrid mode' or 'mixed mode'. It combines **1.5-2.0 hours of weekly class time with substantial required weekly online pre-class preparation, and discussion assignments.**

Assessment and Grade Distribution

Student work in this course contributes to their final grade as follows:

Participation in weekly online discussions	24 %
Research paper/Essay	26 %
Final Exam	50 %

Assessed Activities

Weekly online discussions: Throughout the course, students are required to participate in a number of online asynchronous (non-live, bulletin-board style) discussions hosted in the course discussion forums. Online discussions will be initiated by the instructors and guest lecturers via provocative or critical questions relating to the weekly topic, and will ask students to synthesize ideas as the course proceeds. A primary goal of the online discussions is to promote continuous application of the principles of systems thinking, as new themes are introduced throughout the course. Contributions to at least six discussion forums is expected to be critical and substantive, and will be graded using a scale that reflects these desired qualities. These include: thinking critically about the ideas presented, making connections between ideas presented in the module at hand and the rest of the course (or other science courses), and responding creatively and critically to the discussion question of the week and to peers. In other words, quality of contribution is emphasized and assessed. (For grading scheme see Appendix A)

Research Paper: ISCI 360 will culminate with a final paper in which students will be asked to apply principles of systems science and sustainability in an investigation of a selected aspect of a regional system of their choice. This essay project will be developed in consultation with the instructor(s). It will allow students to pursue a selected topic area of interest in greater depth, and to critically examine factors influencing the status and sustainability of that component of system (for example, water supply or energy systems). (For grading scheme see Appendix B).

Texts

ISCI 360 will make use of one required text, a range of articles drawn from the scientific literature, and selected online video documentaries. These resources offer background material for various topics (for example, basic principles of hydrology or geology), as well as more in-depth presentations of their relevance in regional contexts. Guest lecturers will be consulted on selection of materials, and they may also recommend additional papers from the literature during the course of the term. Where possible, reading materials will be made available online through the course website (and via linkages to UBC Library materials).

The required text is:

- Meadows, D. H. (2008). *Thinking in Systems*. White River Junction, VT: Chelsea Green Publishing.

Course Outline

Week	Topic
1	**Thinking about sustainability** *Dr. Leah Macfadyen, Integrated Sciences* We begin this course by considering sustainability, and the importance of systems approaches, as well as the potential for the sciences to contribute to developing sustainability solutions. As a concept, sustainability goes far beyond principles of environmental preservation, and offers a holistic framework for thinking about how environmental, social, and economic factors all affect the sustainability (or otherwise) of local and global systems. To introduce such a broad topic, this module presents the popular 'three dimensions' model that illustrates how the dimensions of sustainability interconnect, and will explore each of these dimensions in greater depth. It will briefly consider the origin of the concept of sustainable development (SD) and some well-known definitions. ***Required Readings*** • Kates, R. W., Parris, T. M. & Leiserowitz, A. A. (2005). What is Sustainable Development? Goals, Indicators, Values and Practice. Environment: Science and Policy for Sustainable Development, 47(3):8–21. Available online at: http://www.hks.harvard.edu/sustsci/ists/docs/whatisSD_env_kates_0504.pdf • Macfadyen, L. P. (2010). "Sustainability" [lecture notes on this website] ... with material from: Basiago, A. D. (1995). Methods of defining 'sustainability', Sustainable Development, 3: 109-119. • Chapter One. "Deep Ecology - A New Paradigm" (pp. 3-13) of Capra, F. (1996). The Web of Life. New York, NY: Anchor Book.

2	**The Earth System and its biosphere: The day that life nearly died.** *Dr. Stuart Sutherland, UBC Earth & Ocean Sciences* This lecture explores connections between geological events on Earth, and their impact on the Earth System. It reviews the 'Earth System' model and its "spheres", discusses the difference between open, closed and isolated systems, and presents positive and negative feedback as the primary processes of interaction between spheres. The lecture then defines and classifies what is meant by "mass extinction events", and discusses their possible biological, earth-based, and extra-terrestrial causes. In particular, Dr. Sutherland focusses on the Permian / Triassic extinction event and its characteristics, discussing possible causes, effects, and evidence from the geological record. *Required Resources* • Online video lectures available at: http://www.learner.org/resources/series78.html?pop=yes&pid=317 o Plate Dynamics o Geologic Time o Volcanism o Sedimentary Rocks: The Key to Past Environments • Rockström, J. et al. (2009). A safe operating space for humanity. *Nature* 461, 472-475.
3	**Systems thinking** *Dr. Leah Macfadyen, Integrated Sciences* This week's readings and class activities will focus on the idea of 'systems thinking', and will consider the importance of systems approaches when thinking about global sustainability challenges (and possible solutions). ***Required Resources*** • Burch, S. & Harris, S. (2014). Chapter 2: Basic System Dynamics. From the unedited book manuscript for *Climate Literacy*, forthcoming from the University of Toronto Press. • Chapter Two. "From the Parts to the Whole". (pp. 17-35) of Capra, F. (1996). *The Web of Life.* New York, NY: Anchor Books.

4 Water management in a changing world

Dr. Mark Johnson, UBC EOS & IRES

This lecture will present an emerging framework for water management termed the "blue and green water paradigm". Traditionally, water managers have looked towards surface water and groundwater to meet societal water needs (e.g. "blue" or liquid water). However, the majority of precipitation delivered to terrestrial ecosystems is returned to the atmosphere as water vapour (e.g. as the combination of evaporation and transpiration termed evapotranspiration, and referred to as "green" water). In recent years, a movement has started towards explicitly considering green water when discussing water management. In this lecture, the importance of human modification on the hydrologic cycle will be evaluated for both blue water and green water. We will discuss the "Global Virtual Water Trade Network" and what future scenarios might look like for meeting societies water needs as well as the state of water-dependent ecosystems and ecosystem services.

Required Resources

- Hoekstra, A.Y. and M.M. Mekonnen. 2012. The water footprint of humanity. Proceedings of the National Academy of Sciences 109: 3232-3237.
- Gleick, P.H. and M. Palaniappan. 2010. Peak water limits to freshwater withdrawal and use. Proceedings of the National Academy of Sciences 107: 11155-11162
- Online water footprint calculator: http://www.waterfootprint.org/index.php?page=cal/WaterFootprintCalculator
- Meadows, D. H. (2008). "Introduction" and "Chapter ONE: The Basics" (pp. 1-34) in Thinking in Systems. White River Junction, VT: Chelsea Green Publishing.
- Online video lectures (30 mins. each) from the series "Earth Revealed" (1992) developed by Learner.org:
    - 19. Running Water I: Rivers, Erosion and Deposition
    - 20. Running Water II: Landscape Evolution

5 Glaciers and ice caps: Significance, behaviour and future of the cryosphere

Dr. Mauro Werder, SFU Earth Sciences

The objective of this session is that the students gain a fundamental physical understanding of the way glaciers work, appreciate the significance of glaciers to the environment, and be exposed to some of the applied problems that confront a society where ice is part of the culture, landscape and economy. The session will cover the basic physics of glacier formation and flow, emphasizing the controls on glacier mass balance and dynamics. The interplay between glacier, the environment and society will be discussed with examples from Switzerland, in particular with respect to the expected retreat of the glaciers. We will briefly touch on water resource management, touristic implications, natural hazards and hydropower generation.

Required Resources

- TBA
- Online video lecture (30 mins.) from the series "Earth Revealed" (1992) developed by Learner.org:
  - 23. Glaciers
- Selected pages from Chapter Four. "The Logic of the Mind". (pp. 51-71) of Capra, F. (1996). *The Web of Life*. New York, NY: Anchor Books.
- Chapter 2 (pp. 35-72) of Meadows, D. H. (2008). *Thinking in Systems*. White River Junction, VT: Chelsea Green Publishing.

6 Terrestrial ecosystems: Flora and fauna

Dr. Bill Mohn, UBC Microbiology & Immunology

This lecture will give a general introduction to microbial diversity and ecology, with a particular focus on carbon and nitrogen cycling in terrestrial systems (forest and agricultural). The central position of microbes in terrestrial ecosystems will be explored, and the key roles that microbes play in critical chemical cycles within earth systems (carbon, nitrogen) will be discussed.

Required Readings

- 30-minute online documentary from the series *The Habitable Planet: A Systems Approach to Environmental Science*. (Associated text materials may also be useful).
  - Unit 4. Ecosystems
- Costanza, R. et al. (1997). The value of the world's ecosystem services and natural capital. *Nature*, 387, 253-260.
- Selected pages from Chapter Five. "Models of Self-Organization" from Capra, F. (1996). *The Web of Life*. New York, NY: Anchor Books.

7 **The big blue yonder: An introduction to marine ecosystems and processes**

Dr. Jessie Clasen, UBC Zoology

This session will introduce common marine environments (regions such as pelagic, benthic, coastal, oceanic, polar, tropical and temperate), and discuss important physical (temperature, light, currents), chemical (nutrients) and biological (common organisms and food web dynamics) components of marine ecosystems. Case studies will be used to illustrate how connected the oceans are to other ecosystems and to climate.

Required Readings

- Optional: The section entitled *Major Terrestrial and Aquatic Biomes*, in Unit 4. Ecosystems of the series *The Habitable Planet: A Systems Approach* to Environmental Science.
  - *Unit 3. Oceans* of the same series.
- Madin, K. & Nevala, A. E. (Jan. 11th, 2008). Fertilizing the Ocean with Iron. Should we add iron to the sea to help reduce greenhouse gases in the air? *Oceanus* (Woods Hole Oceanographic Institute).
- Chapter 3 (pp. 75-85) of Meadows, D. H. (2008). *Thinking in Systems*. White River Junction, VT: Chelsea Green Publishing.

8 **Climate of the Pacific Northwest: Connections between the atmosphere, ocean and ecology**

Dr. Tara Ivanochko, UBC Earth & Ocean Sciences

In this class we will investigate the connections between the atmospheric dynamics of the North Pacific (specifically the strength of the Aleutian Low pressure system) pacific salmon runs and precipitation. We will consider the Pacific Decadal Oscillation through records of salmon stocks, tree rings, and possibly marine sediments.

Required Resources

- Online video lecture from the series “The Habitable Planet: A Systems Approach to Environmental Science” (2007) developed by Learner.org:
  - Unit 2. Atmosphere
- TBA
- Chapter 4 (pp. 86-110) of Meadows, D. H. (2008). *Thinking in Systems*. White River Junction, VT: Chelsea Green Publishing.

9 **Studying climate change and earth system perturbation**

Dr. Simon Donner, UBC Geography

This lecture will give and overview of the principles of climate change and will present current evidence and predictions regarding effects of climate change on regional systems.

Readings

- TBA
- Pacific Institute for Climate Solutions online learning site '*Climate 101*'
  - Lesson 3: Observable Change (30 mins)
  - Lesson 4: An Introduction to Climate Modelling (30 mins)
- Chapter 5: "Systems traps...and opportunities" (pp. 111-141) of Meadows, D. H. (2008). *Thinking in Systems*. White River Junction, VT: Chelsea Green Publishing

10 **Food systems and the Vancouver food shed**

Dr. Andrew Riseman, UBC Land & Food Systems

Continuing the examination of the 'anthroposphere', this session will examine the context of the global food system including ecological, economic, and social perspectives; components of food systems and their interactions (contrasting global and local); the concept of 'food shed' and its application to Vancouver's food system.

Required Readings

- Dauvergne, P. (2008). "Beef" (pp. 135-167) in *The Shadows of Consumption, Consequences for the Global Environment.* Cambridge, MA: MIT Press. [Available on the course website].
- Pawlick, T. P. (2006). *The End of Food: How the Food Industry is Destroying Our Food Supply – And What We Can Do About It*. Chapters 1,2, and/or 3. Vancouver, BC: Greystone Books. [Available on the course website].
- Halweil, B. & Nierenberg, D. (2007). "Chapter 3-Farming the Cities", in *State of the World: Our Urban Future*. Worldwatch Institute. New York: Norton & Company. [Available on the course website].
- Bentley, S. & Barker, R. (2005). "Fighting Global Warming at the Farmer's Market: The Role of Local Food Systems In Reducing Greenhouse Gas Emissions". *A FoodShare Research in Action Report,* Second Edition April 2005. Toronto: FoodShare. http://www.foodshare.net/resource/files/ACF230.pdf

11 **How science informs urban planning**

Speakers from Metro Vancouver (TBA)

This week's readings and lecture will consider cities as systems, and will examine how different scientific disciplines contribute to urban planning.

Required Reading

- TBA
- Rees, W. E. (2010) "Getting serious about urban sustainability: Eco-footprints and the vulnerability of twenty-first-century cities", in T. Bunting, P. Filion and R. Walker (Eds.), *Canadian Cities in Transition: New Directions in the Twenty-first Century* (pp.70-86). Toronto: Oxford University Press.

12 **Investigating sustainable energy systems**

Dr. John Nyboer, SFU School of Resource and Environmental Management & Canadian Industrial Energy End-use Data and Analysis Centre (CIEEDAC) Energy and Materials Research Group (EMRG)

All activities on earth, whether natural or "anthropocentric", require energy and material flows. Even though the human population exceeds 7 billion people, we are less than 1% of the world's biomass and evidently consume more than 14% of its biological resources. What does the energy and material system look like and how can it be made sustainable? We will look at the science of sustainable energy systems and include some examples from Iceland in our review.

Required Reading

- Cleveland, C. J. & Kaufman, R. K. (2008). In *Encyclopedia of Earth.* Eds. Cutler J. Cleveland (Washington, D.C.: Environmental Information Coalition, National Council for Science and the Environment). [First published in the Encyclopedia of Earth August 29, 2008; Last revised Date August 29, 2008; Retrieved December 21, 2011. http://www.eoearth.org/article/Fundamental_principles_of_energy
- Smil, V. (2012). A Skeptic Looks at Alternative Energy. *IEEE Spectrum*, July 2012, 46-52.

Recommended Reading

- Jaccard, M. (2005). *Sustainable Fossil Fuels.* New York: Cambridge University Press.

13 **What's Blocking Sustainability? Why is the world 'sleepwalking' into a global ecological crisis?**

Dr. Bill Rees, UBC School of Community and Regional Planning

Drawing on current thinking in human ecology/evolutionary biology, cognitive neuroscience, eco-footprint analysis and climate science, this session: 1) briefly examines the ecological state of the world and select 'environmental' trends that pose significant threats to ecological stability and geopolitical security; and 2) asks why the policy responses of both national governments and the world community have been so weak/ineffective in addressing these threats to human well-being. The over-riding question is: "What is blocking real progress toward sustainability?"

Required Readings

- Rees, W. E. (2010). What's blocking sustainability? Human nature, cognition, and denial. *Sustainability: Science, Practice, & Policy*, 6 (2):1-13. http://sspp.proquest.com/static_content/vol6iss2/1001-012.rees.pdf
- Rees, W. E. (2006). "Ecological Footprints and Bio-Capacity: Essential Elements in Sustainability Assessment", in J. Dewulf and H. Van Langenhove (Eds). *Renewables-Based Technology: Sustainability Assessment*. Chichester, UK: John Wiley and Sons. http://www.ecoglobe.ch/footprint/e/rees2006.htm

Appendix A: Assessment Scheme for Online Discussions

The best six grades for participation in online discussions make up 24% of a student's mark for this course. The discussions give students the opportunity to demonstrate their understanding of course ideas, formulate thoughts and questions, and explore ideas further with classmates.

The discussions will be graded individually, out of 10:

10 outstanding, 9 excellent,
8 very good, 7 good,
6 satisfactory, 5 limited,
4 basic, 3 unsatisfactory,
2 and 1 extremely unsatisfactory,
0 did not participate

The qualities for which a student's contributions will be assessed are the following:

- The degree to which the student demonstrates an understanding of the topics treated in the module and familiarity with the assigned resources and readings;
- The degree to which the student gives a critical, analytical, and thoughtful response to the questions under discussion;
- The degree to which the student makes appropriate and illuminating connections between course topics, and learning in other areas/disciplines;
- The degree to which the student interacts well with classmates, demonstrating careful reading of what they have said, supporting and facilitating their participation, and stimulating their further thought;
- The degree to which the students has read the contributions of others (recorded by the software) and made substantial postings to discussions.

Appendix B: Assessment Scheme for Research Paper

The following general assessment criteria describe how student final papers will be assessed summatively.

"A" level (80% to 100%)

A+ is the top of the range, and expresses a percentage grade ranging from 90% to 100%. It is reserved for exceptional students whose performance greatly exceeds course expectations. In addition, achievement must satisfy all conditions below.

A is the middle of the range, from 85% to 89%. A mark of this order suggests a very high level of performance on all criteria used for evaluation. Contributions deserving an A are distinguished in virtually every aspect. They show that the individual significantly shows initiative, creativity, insight, and probing analysis where appropriate. Further, the achievement must show careful attention to course requirements as established by the instructor.

A- is the bottom of the range, from 80% to 84%. It is awarded for generally high quality work, presented with no problems of any significance, and fulfilling all course requirements. However, the achievement does not demonstrate a level of quality that clearly distinguishes it relative to that of peers in class and in related courses. A- work is accurate and meets requirements, but would be improved with creativity or insightful comments. This is the minimum requirement for students taking this course pass/fail.

"B" level (68% to 79%)

This category of achievement is typified by adequate but unexceptional performance when the criteria of assessment are considered. It is clearly distinguished from A level work by any one of three problems:

- one or more significant errors in understanding
- superficial representation or analysis of key concepts
- persistent surface errors (spelling, grammar, punctuation)
- lack of coherent organization or explication of ideas

The level of B work is judged in accordance with the severity of the difficulties demonstrated.

B+ is at the top of the range, 76% to 79%
B is at the middle of the range, 72% to 75%
B- is at the bottom of the range, 68% to 71%

"C" level (55% to 67%)

This level of mark is appropriate as a final grade when some course work is not undertaken and no arrangements are made with the instructor, or, when performance is considered to be too seriously flawed to merit a B grade.

C+ is at the top of the range, 64% to 67%
C is at the middle of the range, 60% to 63%
C- at the bottom of the range, 55% to 59%